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NATIONAL TRANSPORTATION SAFETY BOARD

Washington, D.C.

Advisory Circular 91-71

(17 Pages)



U.S. Department
of Transportation
**Federal Aviation
Administration**

Advisory Circular

Subject: **OPERATION OF HOT AIR BALLOONS
WITH AIRBORNE HEATERS**

Date: 6/13/96
Initiated by: **AFS-820**

AC No: 91-71

1. PURPOSE. This advisory circular (AC) provides guidance for the safe and practical operation of hot air balloons with airborne heaters in compliance with appropriate portions of Title 14 of the Code of Federal Regulations (14 CFR) part 91, General Operating and Flight Rules.

2. DEFINITIONS.

- a. Aeronaut.* A pilot or passenger of a balloon or airship.
 - b. Airborne Heater.* A device carried in the balloon used to generate heat to maintain the temperature of the air inside the balloon envelope. Normally, a propane-powered burner assembly.
 - c. Ascent Profile.* A climbpath over horizontal distance traveled, as applied to obstacle clearance.
 - d. Basket.* A compartment constructed of wicker, occupied by the pilot and passengers.
 - e. Cruise Flight.* A steady state level flight condition without climbing or descending.
 - f. Deflation Port.* A panel in the top or side of a balloon envelope that, when opened/activated (sometimes referred to as "ripping out"), allows a large volume of air to escape from the balloon. It is normally used during landing and/or securing to eliminate the lift of the hot air and deflate the envelope.
 - g. Gondola.* The compartment occupied by the pilot and passengers. It is usually constructed of wicker, metal, or fiberglass.
 - h. Ground Crew (also Chase Crew or Retrieve Crew).* Individuals who track and follow the balloon's flight and assist in launch and recovery operations.
 - i. Hot Air Balloon.* A lighter-than-air aircraft that is not engine-driven and uses hot air for lift.
 - j. Lighter-than-Air Aircraft.* An aircraft that can rise and remain suspended by using contained gas weighing less than the air that is displaced by the gas.
 - k. Pibal (Pilot Balloon).* A small, helium-filled balloon launched before a flight to determine wind direction and velocity and identify windshear. It is used as an aid in selecting a launch site and/or landing site.
 - l. Weight Off.* A command used prior to launch when a rapid initial rate of ascent is needed because of wind and obstacles. The basket/gondola is held to the surface by tether or by the additional weight of crewmembers until sufficient heat can be generated by the burner assembly into the envelope to attain the desired ascent rate. When the necessary heat has been generated, the tether is released or the crewmembers release their hold, allowing the balloon to ascend more rapidly than it would during a normal launch.
 - m. Windshear.* The rate of change of wind velocity (direction and/or speed) per unit of distance, conventionally expressed as vertical or horizontal windshear.
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3. BACKGROUND. Several recent court decisions regarding low flights of hot air balloons indicate a possible lack of understanding by the ballooning public of how various sections of the CFR are applied to hot air balloon operations. This AC has been prepared to help alleviate misunderstandings or misconceptions and to assist hot air balloonists in operating their aircraft within the requirements of part 91.

4. SELECTION OF LAUNCH SITE. The appropriateness of any launch site involves much more than its physical size and absence of obstructions, even though these are important considerations. Of equal or greater importance is the direction the balloon will track following the launch. Any site selection made should include consideration of local winds as determined by pibal, smoke, trees, or other physical indications; forecast and reported winds aloft; and local phenomena peculiar to the specific site (determined by personal knowledge or by consulting with local balloonists). Also, location of obstructions along the projected flightpath and available suitable landing sites down range should be considered. Once a launch site is selected and flight preparations have begun, any situation that may adversely affect or change the planned flight (wind shift, lowering clouds, or obscuring phenomena such as fog or smoke) should be carefully considered. If the change or adverse situation is unacceptable, the launch site should be moved to another location or the flight should be canceled. The adage, "better to cancel and fly another day than to make a mistake along the way," is a useful guideline.

5. TAKEOFF, DEPARTURE, AND CLIMB.

a. Before launching, care should be given to departure and climb considerations. An obstacle assessment should be made. Where powerlines or any other obstacles are present, the pilot should have alternative courses of action available.

b. To compute the minimum distance between the launch point and obstacles downwind, multiply the windspeed expressed in miles per hour (mph) by 100. (See figure 1.) The result is the approximate distance the balloon will travel during its first minute of flight. Next, estimate the height of the obstacle and add the amount of clearance desired when passing over the obstacle; e.g., a 100-foot obstacle plus 200 feet of desired clearance over the obstacle totals 300 feet. Lay the balloon out at least the computed distance from the obstacle. Upon takeoff, establish an initial rate of climb of 300 feet per minute (fpm). The balloon should clear the obstacle by 200 feet. In another example, the windspeed is 4 mph and there is a 75-foot line of trees downwind at the end of the field. Using the above formula, multiply the windspeed by 100 ($4 \times 100 = 400$). In order to pass 100 feet over the trees after takeoff, add 100 feet to the tree height of 75 feet, resulting in a total of 175 feet. Lay the basket at least 400 feet upwind of the treeline. Upon takeoff, establish a minimum initial rate of climb of 175 fpm. The balloon should pass 100 feet over the trees.

Surface Windspeed	Multiplication Factor	Minimum Horizontal Distance
2 MPH	X 100	200 feet
4 MPH	X 100	400 feet
6 MPH	X 100	600 feet
8 MPH	X 100	800 feet
10 MPH	X 100	1000 feet

FIGURE 1. WINDSPEED MULTIPLICATION FACTOR

c. *To provide an allowance for errors* in distance estimation and changes in surface wind or other unforeseen occurrences, pick out a significant landmark halfway to the obstruction. If it should appear that the balloon will not achieve a minimum of half the clearance altitude by that halfway point, immediately terminate the flight by activating the deflation port ("rip out") before reaching a critical altitude (usually about 20 feet above the surface).

d. *With a small launch site and close obstacles*, it may be appropriate to issue the "weight off" instruction before launch to accomplish a rapid initial rate of ascent. Whatever takeoff procedure is used, the ascent profile should ensure safe and expeditious clearance over and around all obstacles along the departure path. It is also important to maintain a positive rate of climb during the departure until the balloon is at or above the appropriate minimum safe altitude prescribed in § 91.119 in VFR conditions.

6. CRUISE FLIGHT. Once established in cruise flight, care must be exercised to maintain visual flight rules (VFR) visibility and cloud clearance requirements (§ 91.155).

a. *Class G Airspace* - 1,200 feet or less above the surface (regardless of mean sea level (MSL) altitude).

(1) Day - 1 statute mile visibility and clear of clouds. (See figure 2.)

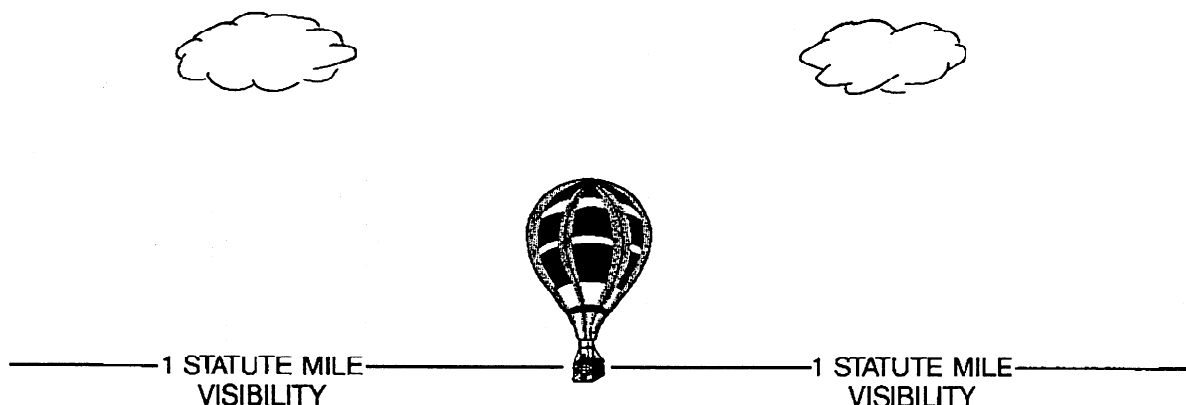


FIGURE 2. CLASS G AIRSPACE 1,200 FEET OR LESS - DAY

(2) Night - 3 statute miles visibility and 500 feet below, 1,000 feet above, and 2,000 feet horizontally from clouds. (See figure 3.) Pilots should consult § 91.126 for additional requirements when operating on or in the vicinity of an airport in Class G Airspace.

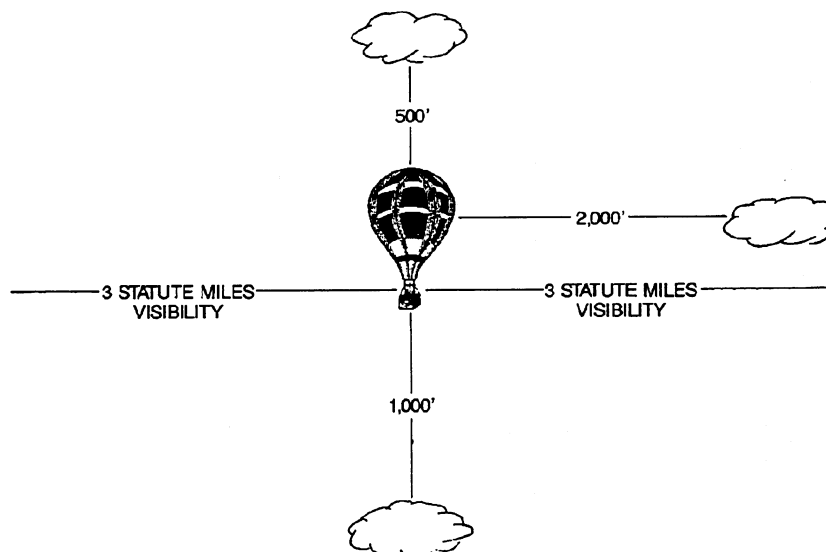


FIGURE 3. CLASS G AIRSPACE - NIGHT

b. Class G Airspace - more than 1,200 feet above the surface but less than 10,000 feet MSL.

(1) Day - 1 statute mile visibility and 500 feet below, 1,000 feet above, and 2,000 feet horizontally from clouds. (See figure 4.)

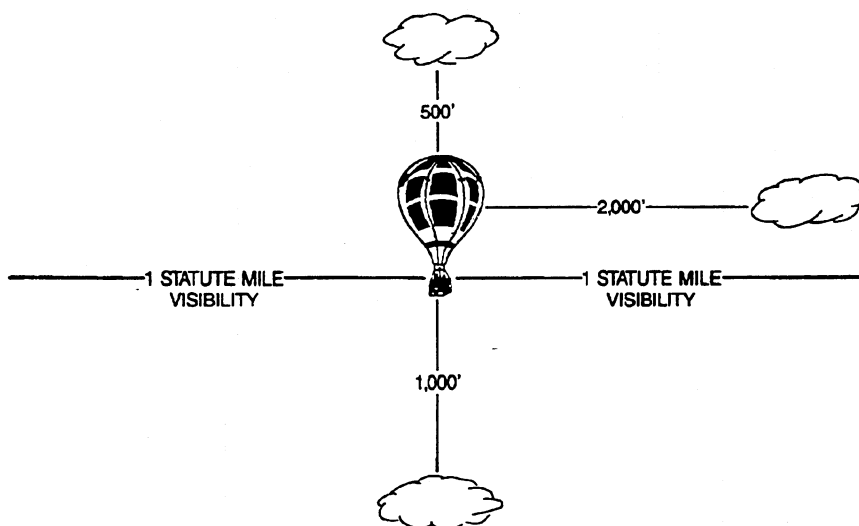


FIGURE 4. CLASS G AIRSPACE MORE THAN 1,200 FEET - DAY

(2) Night - 3 statute miles visibility and 500 feet below, 1,000 feet above, and 2,000 feet horizontally from clouds. (See figure 3.)

c. **Class G Airspace** at more than 1,200 feet above the surface and at or above 10,000 feet MSL - 5 statute miles visibility and 1,000 feet below, 1,000 feet above, and 1 statute mile horizontally from clouds. (See figure 5.)

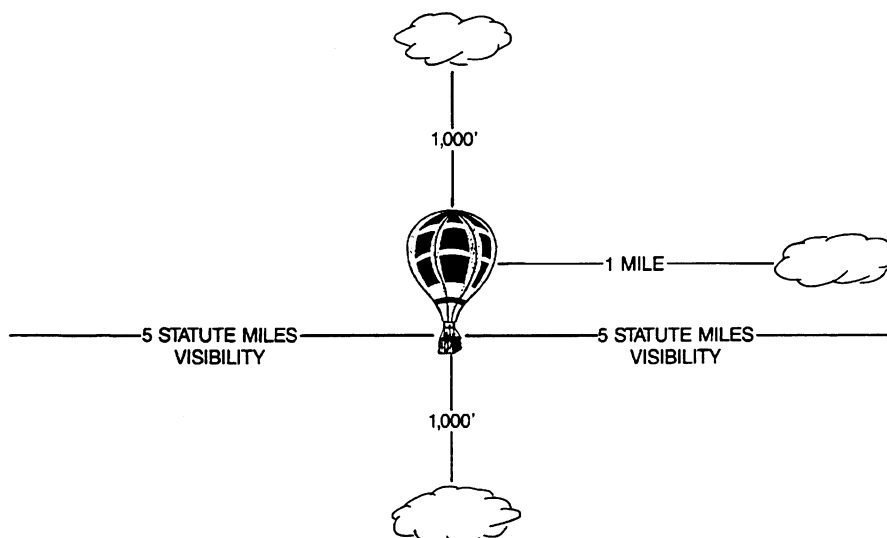


FIGURE 5. CLASS G AIRSPACE AT OR ABOVE 10,000 FEET MSL

d. **Class E Airspace** at less than 10,000 feet MSL - 3 statute miles visibility and 500 feet below, 1,000 feet above, and 2,000 feet horizontally from clouds. (See figure 6.)

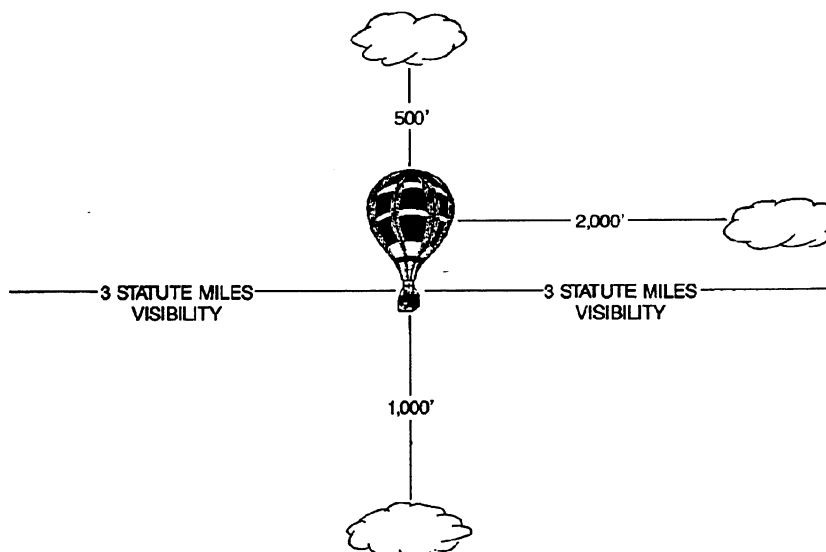


FIGURE 6. CLASS E AIRSPACE AT LESS THAN 10,000 FEET MSL

e. Class E Airspace at or above 10,000 feet MSL - 5 statute miles visibility and 1,000 feet below, 1,000 feet above, and 1 statute mile horizontally from clouds. (See figure 7.) Pilots should consult § 91.127 for additional requirements when operating on or in the vicinity of an airport in Class E Airspace.

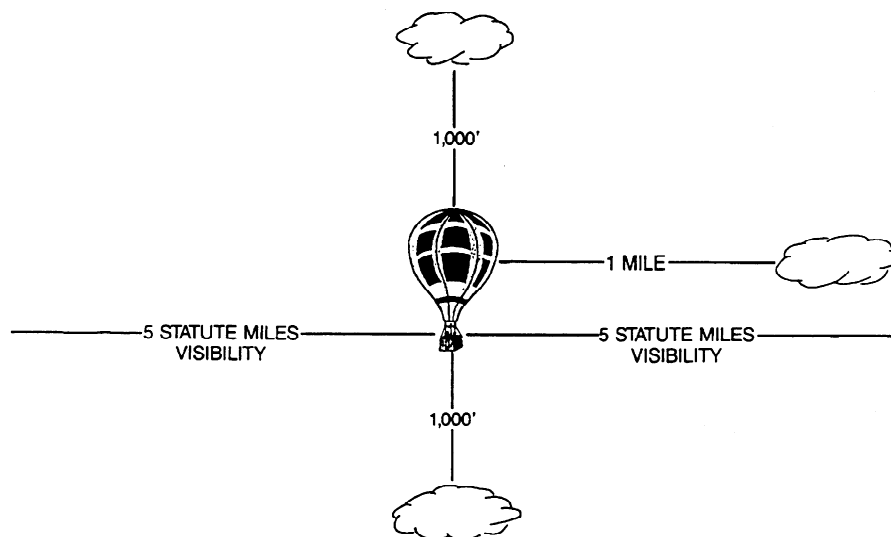


FIGURE 7. CLASS E AIRSPACE AT OR ABOVE 10,000 FEET MSL

f. Class D Airspace - 3 statute miles visibility and 500 feet below, 1,000 feet above, and 2,000 feet horizontally from clouds. Pilots should consult § 91.129 for additional requirements to operate in Class D Airspace. (See figure 6.)

g. Class C Airspace - 3 statute miles visibility and 500 feet below, 1,000 feet above, and 2,000 feet horizontally from clouds. Pilots should consult § 91.130 for additional requirements to operate in Class C Airspace. (See figure 6.)

h. Class B Airspace - 3 statute miles visibility and clear of clouds. Pilots should consult § 91.131 for additional requirements to operate in Class B Airspace. (See figure 8.)

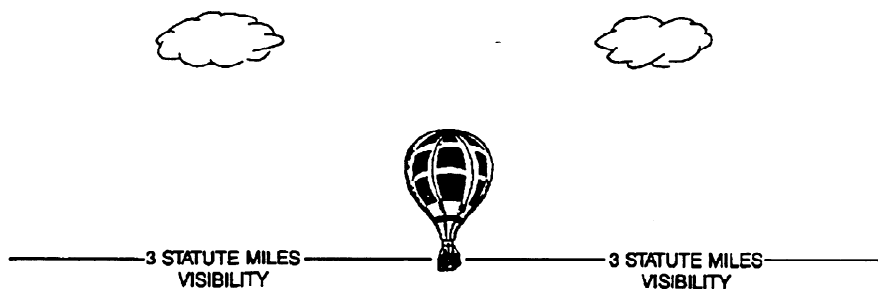


FIGURE 8. CLASS B AIRSPACE

i. **Class A Airspace** - not frequently used by hot air balloons. See § 91.135 for requirements to operate in Class A Airspace.

7. MINIMUM ALTITUDES.

a. **In accordance with § 91.119**, balloons must maintain a safe minimum altitude above the surface and safe minimum distances from obstacles. Section 91.119(b) requires that all aircraft, except when necessary for takeoff and landing, operate over congested areas of cities, towns, or settlements or over open air assemblies of persons at an altitude no lower than 1,000 feet above the highest obstacle within a horizontal radius of 2,000 feet of the aircraft. (See figure 9.)

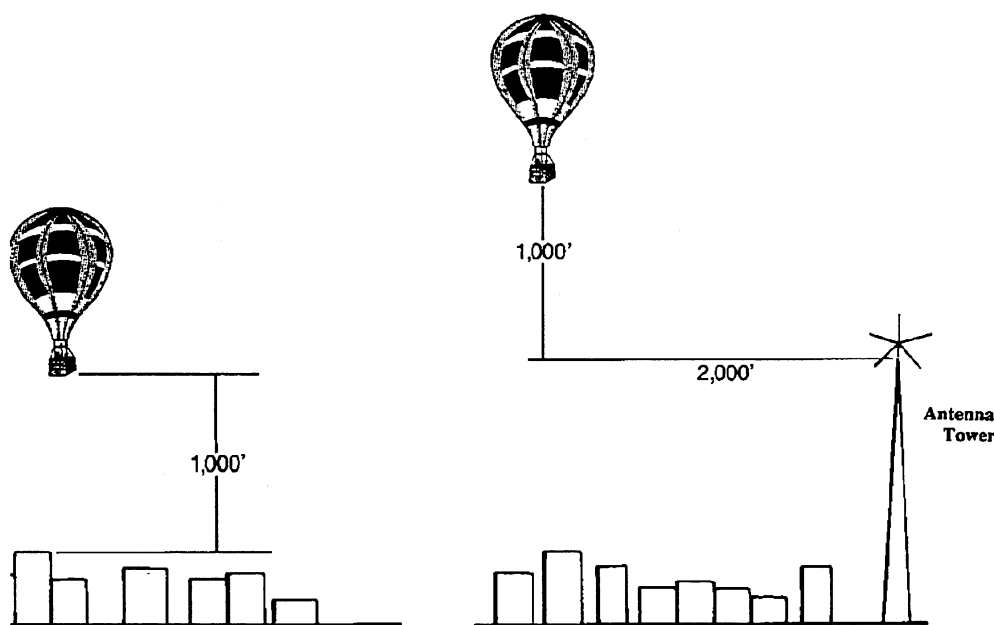


FIGURE 9. OVER CONGESTED AREAS

b. **Section 91.119(c)** requires that all aircraft, except when necessary for takeoff and landing, operate over other than congested areas at an altitude of 500 feet above the surface except over open water or sparsely populated areas. (See figure 10.)

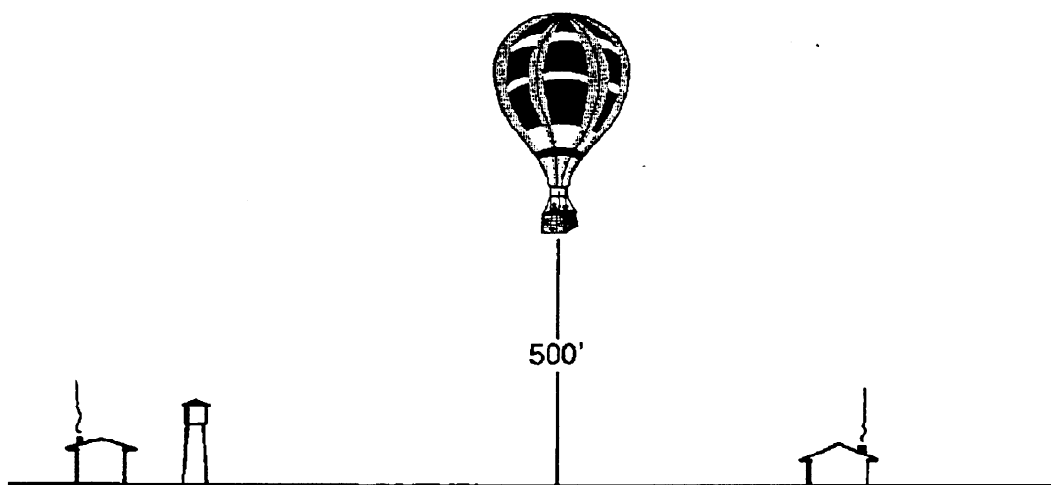


FIGURE 10. OVER OTHER THAN CONGESTED AREAS

c. *In the case of open water and sparsely populated areas,* § 91.119(c) further requires that aircraft operate not closer than 500 feet from persons, vessels, vehicles or structures. (See figure 11.)

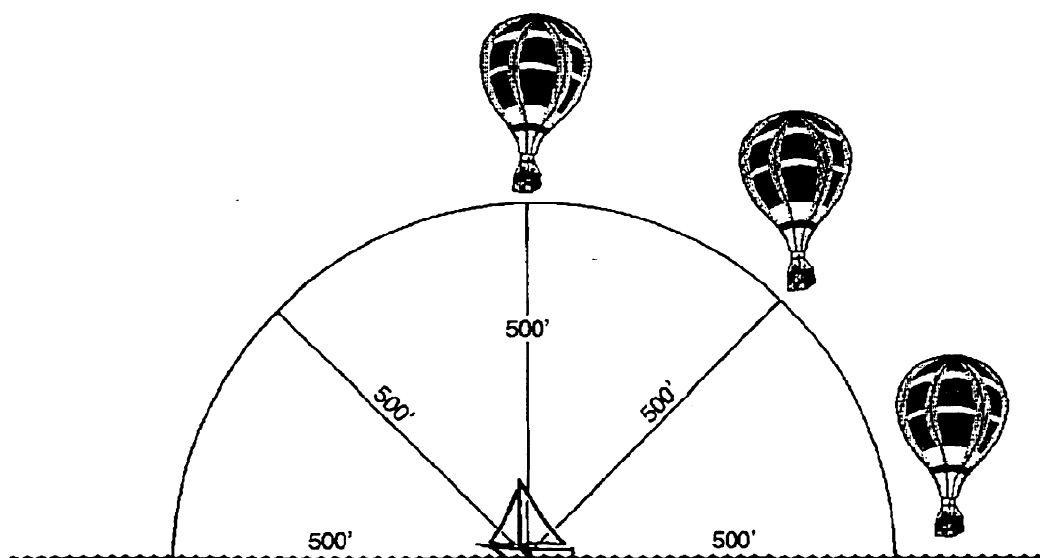


FIGURE 11. OVER WATER AND SPARSELY POPULATED AREAS

8. APPROACH AND LANDING. When a landing site is being considered, consideration should be given to the site's suitability. For example, city streets and highways, small fields occupied by large gatherings of people not associated with the ballooning activity, and fields containing obstructions (such as power lines) may be inappropriate landing sites in certain instances. When considering the prevailing surface wind, aeronauts should make certain that adequate ingress/egress is available with respect to the above obstructions. Before descending below the cruise altitude, aeronauts should keep in mind the need to fly a reasonable descent path to the proposed landing site. The approach to the site may be accomplished in several ways. In a no wind situation, simply settling vertically may suffice; however, when winds are involved, an approach path involving track and descent will be required.

a. Two methods may be used to accomplish an approach path involving track and descent.

(1) A stairstep approach involving varying descent rates may be used. It is important to avoid any long level flight segments below minimum safe altitudes. (See figure 12.) This procedure may be used to determine lower level wind velocities and directions so that options may be considered until the final descent phase to touchdown. There are other methods to evaluate lower level wind conditions such as dropping blades of grass, biodegradable strips of paper, or small balloons. While the descent path can be varied and sometimes may be quite shallow, it is important to avoid level flight segments below minimum safe altitudes. Such level flight periods could lead observers to believe that the pilot has discontinued the approach and established level cruising flight at less than a minimum safe altitude.

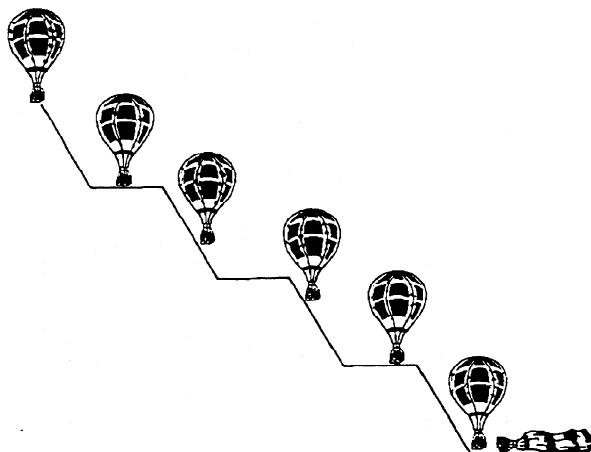


FIGURE 12. STAIRSTEP APPROACH

(2) Another approach procedure is to establish a descent path of approximately 3° , consistent with groundspeed, trading off altitude for distance traveled. However, in some cases, a steeper or shallower descent path may be more desirable. A shallow glidepath of approximately 3 degrees has been established as a general standard by the aviation industry for descents over congested areas. For hot air balloons, this general standard may need to be modified, but it is a good basic guideline. Achievement of a 3° glidepath at a forward groundspeed of 5 knots requires a descent rate of 26 to 27 fpm. A comparison of descent rates versus groundspeed is provided in figure 13. For values not depicted, a straight-line variation may be employed to calculate the descent rate required for a 3° glidepath.

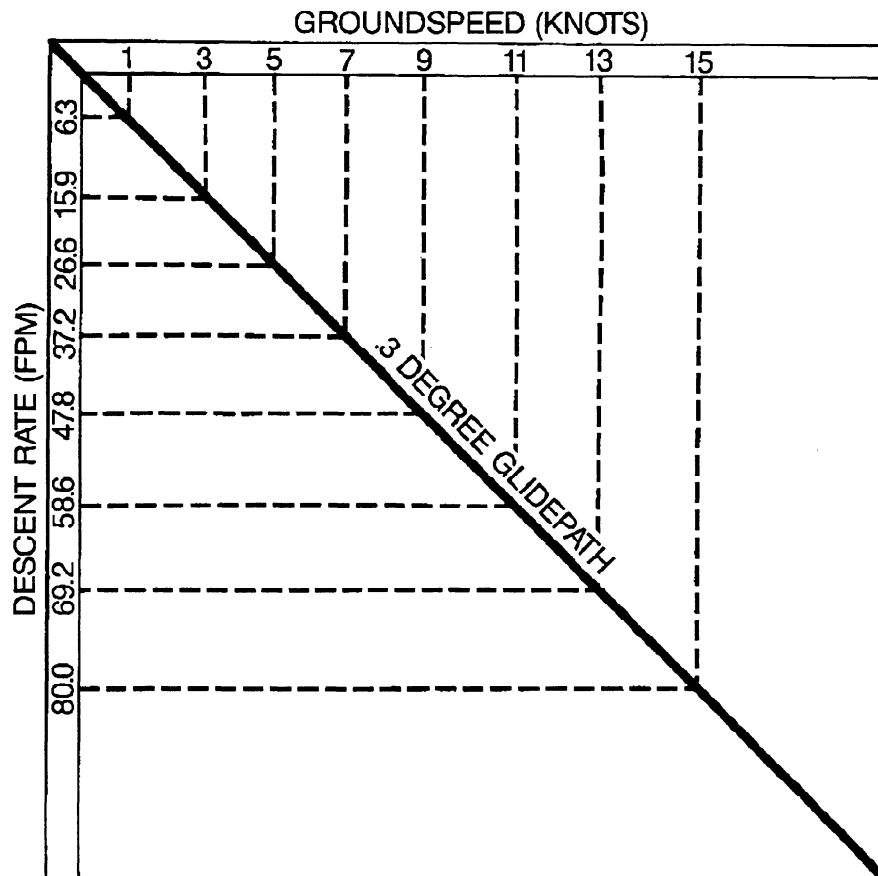


FIGURE 13. DESCENT RATES

b. To successfully accomplish a desired descent path, pilots may elect to use an aim point reference. The aim point is a reference on the ground which, for any given rate of descent, remains constant in the pilot's field of vision during the descent and landing. It is also the point at which the basket will touch down. The aim point will be closer to the basket railing during steeper approaches and closer to the skirt during shallower approaches. However, if the rate of descent, windspeed, and wind direction all remain constant during the approach, the aim point will remain constant in the pilot's field of vision. If the rate of descent, windspeed, or wind direction change, the aim point will start to move. This indicates that the projected touchdown point also is changing. As the changing conditions and the approach stabilize, a new ground location will become constant in the pilot's field of vision, defining the new touchdown point. The new aim point will remain stationary and appear to grow larger as the balloon continues the approach. The challenge for the pilot is to control the rate of descent so that the desired landing point does remain constant in the field of vision throughout the approach. As the pilot looks down the descent path, if an obstacle blocks the pilot's view of the proposed landing site, the descent path is too low to clear the obstacle. Alternately, if the pilot looks down the descent path and no obstacles block the pilot's view of the aim point, the descent path is above obstacles. Use of the aim point reference can provide the pilot advance warning of impending problems.

9. WIND COMPONENTS.

a. *Normally, during level flight in a balloon,* the occupants in the basket feel no wind at all. This is because the balloon has joined an air mass and is moving in the same direction and at the same speed as the air mass (figure 14).

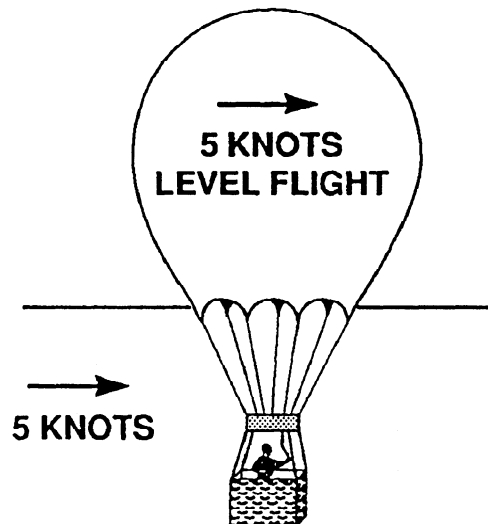


FIGURE 14. WIND SAME DIRECTION AND SPEED

b. *Windshears.* As the balloon climbs or descends, it may transit through wind shears (generally 3 to 7 knots in differential velocity) as the balloon transits from one air mass to another. As the balloon passes through the shear and it transits into a wind which is blowing from another direction or at another speed, the occupants in the basket will momentarily feel a breeze as the envelope "drags" the basket through the lower air mass.

(1) As the balloon climbs through the shear depicted in figure 15, the occupants in the basket will feel a momentary breeze. This is because the envelope is in a different air mass, moving to the left, and dragging the basket through the lower air mass. Once the basket climbs into the same higher air mass, the occupants will cease feeling a breeze and the balloon will change direction, moving in the direction from which the breeze is coming. In other words, the occupants felt a breeze coming from the left and the balloon can be expected to change direction to the left because the upper air mass is moving to the left.

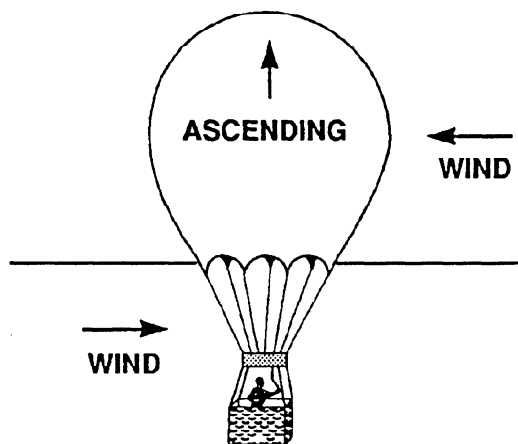


FIGURE 15. ASCENDING THROUGH WINDSHEAR

(2) In a descent, the opposite situation occurs. As the balloon descends through the shear depicted in figure 16, the occupants in the basket will feel a momentary breeze from another direction. This is because the envelope is moving to the left, dragging the basket through the lower air mass. Once the envelope descends into the lower air mass, the balloon will begin to travel in the new direction and the occupants will cease feeling a breeze. Once the envelope fully enters the lower air mass, it will change direction, moving in the opposite direction from which the breeze was felt. In other words, the occupants having felt a breeze coming from the left, the balloon can be expected to change direction to the right because the lower air mass is moving to the right.

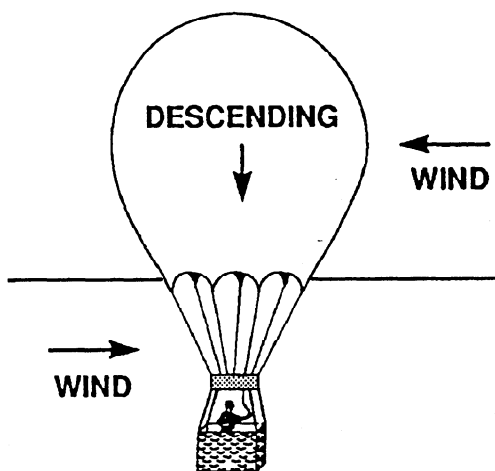


FIGURE 16. DESCENDING THROUGH WINDSHEAR

10. EXCEPTIONS. The previous are rules-of-thumb. Although they are generally accurate, there can be exceptions. For example, if a balloon was descending as depicted in figure 17, the pilot would momentarily feel a breeze from another direction. The rule-of-thumb would lead the pilot to expect the balloon to move to the right but, in this case, the balloon would stop moving when the envelope stabilized in the lower air mass.

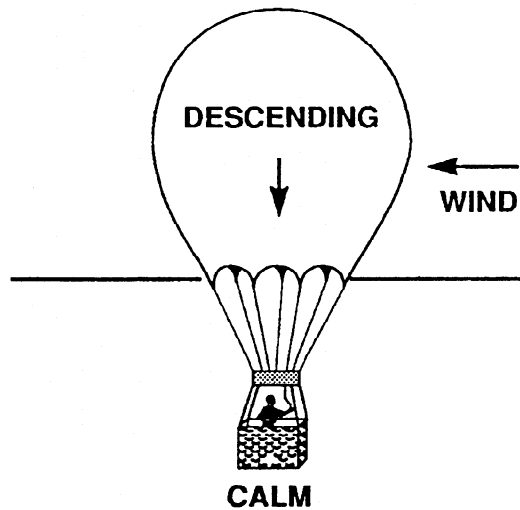


FIGURE 17. DESCENDING INTO CALM AIR

a. If a balloon were descending in the situation depicted in figure 18, the pilot would momentarily feel a breeze from another direction. The rule-of-thumb would lead the pilot to expect the balloon to move to the right. However, in this case, the balloon would continue to move to the left, but at a slower speed once the envelope fully stabilized in the lower air mass.

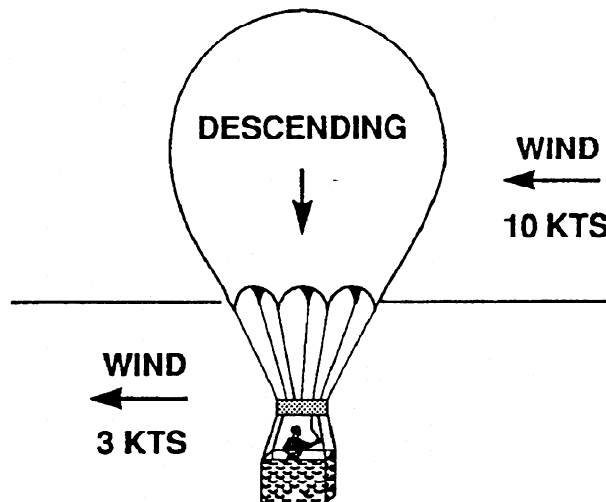


FIGURE 18. DESCENDING INTO DIFFERENT WIND VELOCITY

b. If pilots apply the above rules-of-thumb during climbs and descents and pay attention to gentle breezes, valuable information can be derived. The statement, "the balloon encountered an unexpected wind gust that pushed it into an obstruction before a pilot could react," is an unfortunate corollary to an accident. Application of general rules-of-thumb may provide advance warning and assist pilots to recognize and correct impending problems.

11. ADVISORY MATERIAL. The procedures and techniques discussed in this AC are advisory in nature. They are general guidance and should not be construed as required operating practices. This AC also contains numerous excerpts from, and references to, compliance with part 91. The regulations themselves are not advisory, and compliance is required. Applicable operating limitations and procedures contained in manufacturer's FAA-approved flight manuals, markings, and placards, or as otherwise prescribed by the certificating authority of the country of registry, take precedence over the information contained in this AC.


[Redacted signature area]
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U.S. Department
of Transportation

**Federal Aviation
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